DOCUMENT RESUME

ED 446 987 SE 064 246

AUTHOR	Yoder, Arnita J.
TITLE	The Relationship between Graphing Calculator Use and Teachers' Beliefs about Learning Algebra.
PUB DATE	2000-10-00
NOTE	47p.; Paper presented at the Annual Meeting of the Mid-Western Educational Research Association (Chicago, IL, October 25-28, 2000).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Algebra; Elementary Secondary Education; *Graphing Calculators; Mathematics Education; Questionnaires; *Teacher Attitudes

ABSTRACT

The purpose of this study was to determine teachers' views of learning algebra and to investigate if any relationship exists between their views of learning algebra and the ways that they use graphing calculators in their algebra classes. The 48 algebra teachers who participated in the study were from Allen, Putnam, and Van Wert counties in northwest Ohio. The participants completed a survey which included both background questions and four-point Likert-scale statements concerning graphing calculator use and views of learning algebra. When calculator use was examined in regard to the teachers' views of learning algebra and also to the teachers' background characteristics, workshop attendance was found to be an important factor in determining how the teachers use calculators. The results also showed that a majority of the algebra teachers who use calculators in these three counties are currently using the Texas Instruments TI-83/TI-83 Plus calculator and that they are using them at least several times per week for in-class activities, homework, quizzes, and tests. The teachers' views of learning algebra were not found to be a significant factor in calculator use. (Contains 49 references.) (Author)

The Relationship Between Graphing Calculator Use and Teachers' Beliefs About Learning Algebra

Arnita J. Yoder
Bluffton College

Paper presented at MWERA
October 25-28, 2000
Chicago, IL

ABSTRACT

The purpose of this study was to determine teachers' views of learning algebra and to investigate if any relationship exists between their views of learning algebra and the ways that they use graphing calculators in their algebra classes. The 48 algebra teachers who participated in the study were from Allen, Putnam, and Van Wert counties in northwest Ohio. The participants completed a survey which included both background questions and four-point Likert-scale statements concerning graphing calculator use and views of learning algebra. When calculator use was examined in regard to the teachers' views of learning algebra and also to the teachers' background characteristics, workshop attendance was found to be an important factor in determining how the teachers use calculators. The results also showed that a majority of the algebra teachers who use calculators in these three counties are currently using the Texas Instruments TI-83/TI-83 Plus calculator and that they are using them at least several times per week for in-class activities, homework, quizzes, and tests. The teachers' views of learning algebra were not found to be a significant factor in calculator use.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I - INTRODUCTION

Background

Since the first hand-held four-function calculator was marketed in 1974, professional organizations such as the National Research Council, the Mathematical Sciences Education Board (MSEB), and the National Council of Teachers of Mathematics (NCTM) have supported calculator use in elementary and secondary schools (Reys, et al., 1990). The NCTM has also advocated the use of graphing calculators in a statement that calls specifically for "scientific calculators with graphing capabilities to be available to all students [grades 9-12] at all times" (NCTM, 1989, p. 124).

Research has shown that the appropriate use of calculators can positively affect mathematics instruction by enabling a shift away from lecture-based learning towards inquiry-based learning (Bitter & Hatfield, 1992; Tharp, Fitzsimmons, & Brown Ayers, 1997). In a recent study, when teachers were asked how their classroom dynamics were altered by using graphing calculators, several major trends (answers given by at least 50% of the teachers) emerged, all of which were related to inquiry-based learning (Simonsen & Dick, 1997). The teachers reported that their classrooms were less teacher-centered and that they made more use of open-ended questioning and discovery methods of instruction. An increase in cooperative learning was also noted with "students…taking more responsibility for their own learning as well as working together with their peers and helping each other learn" (Simonsen & Dick, p. 255). Simonsen and Dick's findings agree with those of an earlier study where teachers who used graphing calculators were found to

give fewer lectures and to promote "more interactive and exploratory learning environments" (Dunham & Dick, 1990, p. 444).

Although the teachers in Simonsen and Dick's (1997) study indicated enthusiastic responses from both themselves and their students to the classroom changes that had occurred due to calculator use, research has shown that mathematics teachers are often reluctant to use calculators due to their "beliefs about what mathematics is and what their role as a mathematics teacher includes" (Reys, et al., 1990, p. 29). Although the voiced concerns are often limited to logistical issues such as calculator funding and security (Reys, Reys, & Wyatt, 1993), the real quandary may include much more than that. Implementing any new form of instruction, including calculator use, requires teachers to look closely at their "philosophies of learning, their attitudes and beliefs about learners and mathematics and...to make changes in how and what they teach" (NCTM, 1991, p. 125). Unfortunately many teachers are hesitant to make such changes, and according to Kramer (1996), mathematics teachers are even more resistant to change than teachers in other areas. Teachers who have always taught in teacher-centered classrooms are sometimes uncomfortable with the unpredictability of calculator use and the "unanswerable" questions that may occur when conducting calculator explorations (Dunham & Dick, 1994). The successful use of calculators also requires teachers to give up some classroom control which is difficult for many lecture-oriented mathematics teachers (Tharp, et al., 1997).

Since all teachers have beliefs about learning that influence their teaching styles (Thompson, 1984), it is essential that "the relationship between a teacher's philosophical orientation and beliefs about the use of calculators in the classroom...be understood and

accounted for before efforts to change teaching practices by including technology can be successful" (Fleener, 1995, p. 496). Although previous research has been conducted concerning the relationship between calculator use and teachers' philosophies of mathematics, the need for further research exists. Fleener has called for continued investigation of the calculator issue to help "provide further insight into the complex relationships among beliefs, experience and philosophy" (p. 497), Penglase and Arnold (1996) have recommended further examination of teaching styles as they relate to graphing calculator use, and Lindquist, et al. (1991, as cited in Simonsen & Dick, 1997) believe that it is important to investigate any obstacle that stands in the way of implementing technology at the secondary level.

Purpose of the Study

The purpose of this study was to investigate the ways high school algebra teachers use graphing calculators in their classrooms, and to explore the connections between the ways calculators are used and the teachers' beliefs about learning algebra. The following questions will be considered:

1. How do high school algebra teachers use graphing calculators in their classrooms?
2. What are the teachers' beliefs about learning algebra?
3. Is there a relationship between the ways teachers use graphing calculators and their beliefs about learning algebra?

Definition of Terms

In this study, *four-function calculator* will refer to any non-scientific hand-held calculator, while *graphing calculator* will indicate any hand-held calculator which "provides all the facilities of a scientific calculator as well as capabilities for data analysis, linear algebra, programming, and...the graphing of functions" (Penglase & Arnold, 1996, p. 59). Symbolic calculators that "manipulate not just numerical data but also symbolic quantities" (Ralston, 1991, p. 18), will not be included in the discussion of graphing calculators.

CHAPTER II - LITERATURE REVIEW

The research examined in the first portion of the literature review refers to calculator use in general. Although most of the literature concerns standard four-function calculators, it should be noted that the issues discussed (basic computational skills, mathematics curriculum, and standardized testing) apply to graphing calculators as well. The second section of the literature review focuses on information that pertains solely to graphing calculator use.

General Calculator Issues

In the twenty-five years since Texas Instruments introduced the first hand-held electronic calculator much discussion has occurred regarding its place in mathematics education. Mathematics educators at all levels have voiced strong opinions on both sides of the calculator issue, and the topic of calculator effectiveness has been one of the most significant research endeavors in mathematics education (Suydam, 1982, as cited in Hembree & Dessart, 1992). Although opinions and research topics vary, three general themes emerge in much of the literature regarding calculator use. They are as follows:

1. How calculator use affects basic computational skills.
2. How the mathematics curriculum changes when calculators are introduced.
3. How standardized testing is affected by the use of calculators.

Basic Computational Skills

With the wide-spread use of calculators, there arose a common perception that as students became more reliant on technology, they would never learn basic computational skills (Dion, 1990; Hembree & Dessart, 1992). According to Dick (1988, as cited in Ostapczuk, 1994), the importance of obtaining these basic computational skills has always been the main issue of concern surrounding calculator use. Although research has shown that using calculators results in no measurable decline of computational skills, with the exception of long division (Hembree & Dessart, 1986, as cited in Burrill, 1997), the belief that the calculator is "an instrument of mental destruction" (Gilchrist, 1993, p. 4) remains prevalent in today's society.

In an attempt to resolve the issue of basic computational skills, Hembree and Dessart (1992) conducted an extensive examination of calculator effectiveness studies, and, as mentioned above, concluded that no decline in computational skills occurred at the high school level and that "calculator use for instruction and testing enhanced learning and the performance of arithmetical concepts and skills" (p. 30). A study by the National Research Council and the Mathematical Sciences Education Board (1989, as cited in Dion, 1990) also noted that no difference in computational skills existed between students who did and did not use calculators, and in addition, found that students who used calculators had better problem-solving skills and better attitudes toward mathematics than students who did not. The research examined by Hembree and Dessart, along with an extended meta-analysis by Smith (1997, as cited in Dessart, DeRidder, & Ellington, 1999) yielded similar results on the issues of problem solving ability and student attitudes toward

mathematics, and according to Merriweather and Tharp (1999), "the use of graphing calculators is likely to increase both the competence and the confidence of students" (p. 8).

Proponents of calculator use often point out that the 1989 NCTM *Curriculum and Evaluation Standards* do not require mastery of paper and pencil skills (Mercer, 1992) nor does the mastery of paper and pencil skills imply understanding or guarantee the ability to apply those skills in real-life situations (Baggett & Ehrenfeucht, 1992; Maier, 1983; Usiskin, 1984). This view is expressed well by Shankar who stated that "our youngsters are doing better at memorizing rules and applying them in a rote fashion – but, often they don't have a clue about what they're doing or what it all means" (Shankar, 1988 as cited in Baggett & Ehrenfeucht, p. 62). Other calculator proponents believe that "employing the most efficient means possible to solve a problem is the essence of good mathematics" (Usiskin, p. 83) and that math teachers often violate both good mathematics and common sense by denying students the technology available to solve problems effectively. According to Baggett and Ehrenfeucht, a good rule would be: "Let the teacher explain. Let the student think. Let the computer [calculator] do mindless work" (p. 68).

Curriculum

The argument involving basic computational skills and paper-and-pencil algorithms leads to the more fundamental issue of "what is truly important in mathematics" (Mercer, 1992, p. 417). The NCTM has called for a broader view of learning and teaching and it has been stated that "technology [such as calculators] holds unlimited potential for significantly changing both what is taught (curriculum) and how it is taught (instruction) in

secondary school mathematics" (Reys, et al., 1993, p. 261). Waits and Demana (1996) propose that traditional paper and pencil arithmetic be transformed to a mathematics that is "more technologically enhanced, richer, more interesting, and more applicable" to the future (p. 714). Heid (1988) agrees that the current high school mathematics curriculum is outdated and that "it is time to stop preparing students for the past and start preparing them for the future" (p. 713).

Calculator opponents fear that by including calculators in the curriculum, time will not be available for other topics (Simonsen & Dick, 1997; Tress, 1998), while proponents believe that the inclusion of calculators can actually liberate students from time-consuming calculations and allow more time to cover challenging mathematical material (Burrill, 1999; Glasgow & Reys, 1998). As a shift in curriculum occurs, with less emphasis on computation and more emphasis on concept development (Heid, 1988), teachers must decide which of the mechanical procedures included in the current mathematics curriculum are actually necessary and which can be de-emphasized or totally removed due to the availability of calculator technology (Mercer, 1992; Milou, 1999; Penglase & Arnold, 1996; Waits & Demana, 1996).

Standardized Testing

Despite the belief that "math instruction should exploit the power and convenience of calculators and computers, and the circumstances of testing should be compatible with the circumstances of instruction" (Association of State Supervisors of Mathematics, 1992, as cited in Gilchrist, 1993, p. 33), it has been the standardized testing ban on calculators that has often discouraged calculator use in daily mathematics instruction (Bitter &

Hatfield, 1992). Although the College Board does allow calculator use on the SAT (Milou, 1999) and the Ohio Department of Education will begin furnishing calculators in 2002 for use on the newly developed High School Graduation Qualifying Examination (Mikesell, 2000), as long as many standardized and state required proficiency tests remain computation-oriented and ban calculator use, teachers will be forced to teach computation skills and de-emphasize calculator use in their classrooms. Since curriculum and testing exist in a "circular situation [where] testing follows instruction and [likewise] instruction follows testing" (Gilchrist, p. 32), if the standardized testing industry begins to modify tests to contain more free-response questions that emphasize problem-solving and realistic data, the mathematics curriculum will also change to represent such subject-matter (Ralston, 1991). By allowing calculator use, the standardized testing industry has the power to force curriculum changes, and thus the implementation of the NCTM evaluation and assessment standards (Kenelly, 1990).

Graphing Calculators

With the development of the graphing calculator in 1985, came a resurgence of calculator research. According to Burrill (1992), "just as the four-function calculator challenged the role of pencil-and-paper skills in arithmetic and the goals of elementary school mathematics, graphing and programmable calculators are forcing a serious examination of the secondary school curriculum" (p. 15). As previously mentioned, much of the research concerning graphing calculators mirrors that of four-function calculators, with studies concerning paper-and-pencil graphing skills, mathematics curriculum changes and standardized test implementation (Usiskin, 1999). Due to the additional concern that

the "extensive use of calculator and computer tools, with corresponding de-emphasis of training in skills, will undermine development of conceptual understanding, proficiency in solving problems and ability to learn new advanced mathematics" (Fey, 1990, as cited in Burrill, p. 20), two additional issues occur in much literature regarding graphing calculators. They are as follows:

1. How graphing calculator use affects student learning in relation to conceptual understanding and problem solving ability.
2. How graphing calculator use is related to teachers' philosophies and beliefs about how students learn mathematics.

Student Learning

Many mathematics educators and organizations believe that the mathematics curriculum should shift its emphasis from computation to problem solving and conceptual understanding (Demana & Waits, 1990 as cited in Simonsen & Dick, 1997). In a 1990 Missouri calculator status report, 57% of the teachers interviewed believed that graphing calculators were useful tools for both concept development and problem solving (Reys, et al., 1990). Other math teachers believe that their students' ability to solve problems by making connections and seeing patterns has improved with graphing calculator use (Klenow, 1993; Simonsen & Dick), and that the calculator "helps students gain new insight into the power and intricacy of mathematics" (West, 1991, p. 18). Research has shown that graphing calculator use can improve conceptual understanding by allowing students to connect algebra to its graphic representations (Burrill, 1992; Drier, Dawson, & Garofalo, 1999) and to better understand relationships among mathematical concepts

(Waits, 1990, as cited in Trotter, 1991). The graphing calculator also allows students to "gain a deeper understanding of functions and their graphs by interactively using the graphics and algebraic capabilities of calculators" (Dion, 1990, p. 564). In an analysis of graphing calculator research related to student learning, Dunham and Dick (1994) found nine studies that reported positive increases in students' conceptual understanding and only two studies where no improvement had occurred. Penglase and Arnold (1996) also investigated calculator research and noted similar results, concluding that students who use graphing calculators have a stronger conceptual base of understanding than those who do not.

Research concerning graphing calculator effects on problem solving ability has shown that calculator use leads to improved problem-solving skills by decreasing computation time, thus allowing more time to analyze problems (Drier, et al., 1999; Klenow, 1993; Podlesni, 1999), and according to one teacher, "students will attempt a multistep difficult problem with a calculator but not without one" (Ballheim, 1999, p. 5). Drijvers and Doorman (1996) observed students over a four year period and found problem solving to be enhanced by graphing calculators since problems could represent actual real-life situations and not be limited to contrived numbers for the sake of easy computation. Drier, et al. agree that calculator exploration allows for "in-depth exploration of mathematical topics previously too complex for typical classrooms, especially when they involve real-world 'messy' data" (p. 21). By giving direct feedback, using calculators also allows students to make changes and improvements and to concentrate on solutions and conclusions as opposed to computation (Drijvers & Doorman; Merriweather & Tharp, 1999), and according to Burrill (1999), students "are

ready to investigate any option [with calculators], they accept a challenge, and they…are doing things they never would have done before" (p. 13). The programming aspect of graphing calculators has also been shown to aid in problem solving by empowering students to "experiment, conjecture, [and] ask questions that would have been walked away from before" (Tress, 1998, p. 24). The view of graphing calculator use as it relates to problem solving can be summed up in a statement made by a math teacher, "It allows students to direct mental energy toward the better aspect of problem solving, intuition, deduction and that sort of thing…and not get bogged down with computation" (Reys, et al., 1990, p. 6).

Teacher Philosophies

Much research regarding graphing calculators focuses on the enhancement of student learning and the improvement of student achievement through calculator use (Milou, 1999; Penglase & Arnold, 1996; Simmt, 1997). Unfortunately, it is difficult to measure learning as it relates solely to calculator use since the use of calculators cannot be isolated from the many other variables involved in classroom dynamics. "No one believes that simply carting a set of graphing calculators into a classroom will have some magical effect on students" (Dunham & Dick, 1994, p. 441), so before claims can be made about calculator effectiveness, the context of use must be considered. The results of a calculator project by Bitter and Hatfield (1992) showed that the way teachers used calculators directly influenced the levels of student achievement and attitude, and after examining calculator research and noting student attitude changes, Penglase and Arnold questioned whether the attitude improvement was a response to the calculators themselves or to the

instructional methods being used. It appears that all research pertaining to graphing calculators must be interpreted in light of the learning environment where the calculator use occurred (Milou; Penglase & Arnold).

A study conducted by Jost (1992, as cited in Penglase & Arnold, 1996) concerning teachers' beliefs and practices as related to calculator use showed that teachers who believed in using inquiry and discovery-based instructional methods made more use of calculators than those who did not. Tharp, et al. (1997) also found a high correlation between teachers' beliefs about mathematics and their use of graphing calculators. They noted that teachers with rule-based views of mathematics believed that graphing calculators hindered mathematics instruction and were quick to return to traditional teaching styles after experimenting with calculator use. Even when using calculators, they chose activities where the amount of calculator use could be carefully controlled. Teachers with non-rule-based views, however, saw calculators as a benefit to instruction and were more willing to use them on a regular basis (Tharp, et al.). Fine and Fleener (1994) studied three preservice teachers' views of calculators and found similarly that the teachers'

> "view of mathematics as a body of rules to memorize and skills to perfect, not as patterns and relationships to explore and discover, seemed to be their hurdle, their stumbling block which prevented them from perceiving calculators as anything other than computational, time-saving tools" (p. 96).

Simmt (1997) interviewed teachers regarding calculator use and noted that teachers generally viewed mathematics as either a collection of skills or as a process of discovery. She found that both views were evident in teachers' "choices of activities for

use with the graphing calculator, the kinds of questions they asked students, and in other interactions with their students" (p. 283). She concluded that teachers' views about mathematics were not changed, but rather strengthened by using graphing calculators and that the "availability of the graphing calculator simply provided… teachers with an opportunity to further live their philosophies of mathematics and mathematics education" (p. 286).

Fleener (1995) surveyed teachers using the Attitude Instrument for Mathematics and Applied Technology (AIM-AT) and found that beliefs about mathematics, especially the belief that students should master skills before using calculators, were the key to how teachers used calculators in their classrooms. Teachers who believed that skills should be mastered before calculator use was permitted, usually failed to see the importance of calculator use beyond checking paper and pencil work.

It is evident from previous research that teachers' views of mathematics are a key to how they teach mathematics (Thompson, 1984) and also to how they use calculators in their classrooms. Consequently, before calculators can be successfully implemented into the mathematics curriculum, it is important to understand the attitudes, beliefs and philosophical perspectives of mathematics teachers (Fleener, 1997). According to Simmt (1997), "providing a new tool is not sufficient to change instruction since one's philosophy of math is manifested in one's instruction of math" (p. 287).

CHAPTER III - METHODOLOGY

The purpose of this study was to explore what, if any, relationship exists between teachers' use of graphing calculators and their beliefs about learning of algebra. Since this study investigated these possible relationships by collecting and analyzing numeric data, quantitative methods were employed. In order to collect data from a local population of teachers, this study made use of a questionnaire approach. This methodology was chosen because of its efficiency, in that it "required less time, was less expensive, and permitted collection of data from a much larger sample" (Gay, 1996, p. 255) than many other data collection strategies.

Subjects

The subjects in this study were the Algebra I and Algebra II teachers from the high schools in Allen, Putnam, and Van Wert counties in northwest Ohio. This particular three-county area was chosen because it surrounds the Delphos City School district and is of particular interest to the researcher. The 23 schools in these three counties include nine high schools with a student population under 300, nine high schools with a student population between 300-600, four high schools with a student population between 600-900, and two high schools with a student population over 900. Two schools in these counties are parochial schools, while 21 are public school systems.

A total of 54 Algebra I and Algebra II teachers were included in the study. The respondents included 24 males and 24 females, giving a total of 48 participants and a 88.9% return rate. Of the 48 participants, 21 (45.8%) taught Algebra I, 16 (33.3%)

taught Algebra II, and 11 (22.9%) taught both subjects. Educationally, 23 participants (47.9%) held a bachelors degree, 11 (22.9%) held a masters degree, and 14 (29.2%) had completed some education beyond the masters level. The participants had taught math an average of 16 years, with 19 participants (39.6%) teaching less than 10 years, 9 (18.8%) teaching between 11-20 years, 16 (33.3%) teaching between 21-30 years, and 4 (8.3%) teaching over 30 years.

Instruments

In this study, data was obtained by means of a survey instrument with questions taken from Bitter & Hatfield (1994), Fleener (1995), Huang (1993), Merriweather & Tharp (1999), and Tharp, et. al. (1997) and modified by the researcher. The survey was reviewed by four of the researcher's colleagues to ensure that the intent of each question was clear and, based on their suggestions, several modifications were made before the final survey was mailed.

In its final form, the survey consisted of 24 questions (see Appendix A). The first 12 questions requested background information from the participant, such as age, gender, and highest degree earned. Information about teaching assignment and calculator use was also requested, including the algebra classes taught, the number of years teaching math, the number of years using calculators, the number of calculator workshops attended, the brands and models of calculators used, the types of activities for which calculators are used, and the frequency of calculator use. Questions 13-24 were four-point Likert-scale statements (with choices ranging from 1 = Strongly Disagree to 4 = Strongly Agree)

concerning calculator use (items #13-21) and beliefs about learning algebra (items #22-24).

Procedures

In January, 2000, a list of Algebra I and Algebra II teachers in Allen, Putnam, and Van Wert counties in Ohio, along with their school addresses, and school demographic information was compiled from individual school web-sites, the Ohio Department of Education web-site, and contacts with school guidance counselors and teachers in the specific districts.

The graphing calculator survey was written in January, 2000 and submitted to four teachers to check for validity. Using suggestions from the teachers, the survey was revised and mailed to 54 algebra teachers on February 7, along with a cover letter explaining the nature of the study, and a self-addressed, stamped envelope for return of the survey. On February 22 a follow-up letter was sent to the 13 teachers who had not returned their survey, resulting in 7 additional responses for a total of 48 returned surveys. See Appendix A for copies of the cover letter, the graphing calculator survey, and the follow-up letter.

Limitations/Assumptions

This study was quantitative in nature and made use of a questionnaire approach, thus some limitations exist due to the methodology chosen. First, although the graphing calculator survey was mailed to every Algebra I and Algebra II teacher in Allen, Putnam and Van Wert counties, there was no control over the actual sample and no way to judge

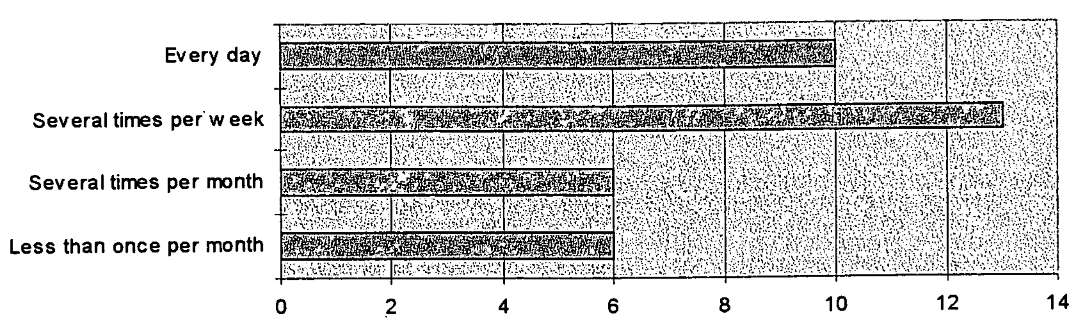
if the teachers who returned the survey were more or less favorable toward calculator use than those who did not. Also, despite the teacher review and subsequent revision of the survey questions, they were still open to individual interpretation which may challenge the validity of the answers given.

Another limitation exists in sample size. Even though 88.9% of the surveys were returned, the sample size of 48, with only 36 actual calculator users, was relatively small and thus the generalizations are limited. A larger sample may have shown significant results on certain questions where the results were relatively close to the critical values. It is also not known how this three country area, which is predominantly rural in nature, compares demographically to the entire state, or to the country, which limits the generalization of results.

CHAPTER IV - RESULTS

On the first page of the graphing calculator survey teachers answered general background questions regarding their calculator use. The information requested included the number of calculator workshops they had attended, the calculator brands and models their students use, the type of activities for which their students use calculators, and the frequency of their calculator use. The answers given by the 48 respondents were compiled, and in regard to calculator use, 36 (75%) participants stated that they use graphing calculators in their algebra classes, while 12 (25%) do not. The 36 teachers who use calculators were asked to report on their frequency of use (every day, several times per week, several times per month, or less than once per month) with the results shown in Table 1. The differences were not significant at the .05 level by chi-square test [χ^2 (3, n = 35) = 3.97].

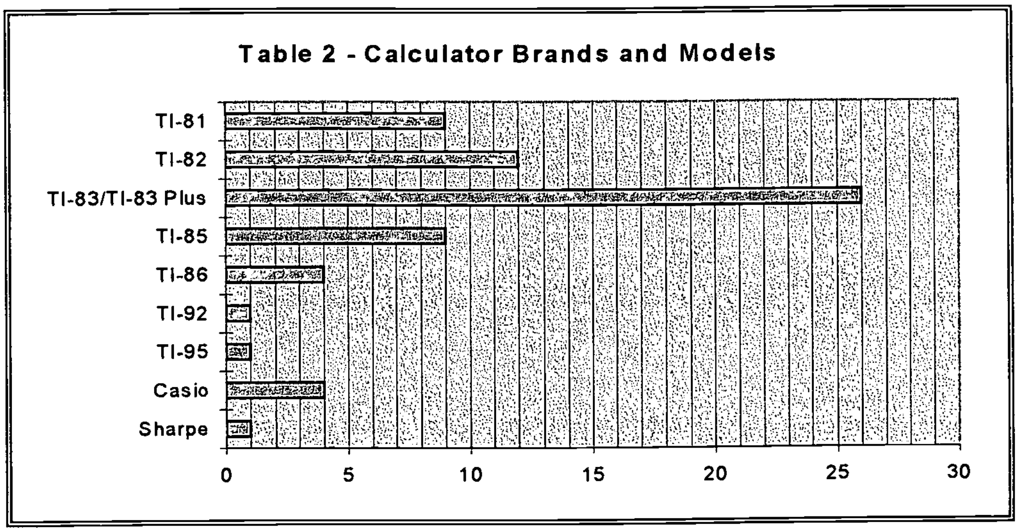
Table 1 - Frequency of Calculator Use



When asked for the type of activities in which calculators are used, a majority of the teachers (77.8%) reported that they allow calculator use for in-class activities, homework, quizzes, and tests. Five teachers (13.9%) allow calculator use for in-class

activities only, while one teacher (2.8%) allows calculator use for everything except quizzes and two teachers (5.6%) allow them to be used for everything except homework.

The teachers were also asked what brand and model of graphing calculator they use in their algebra classes, and although many of the teachers reported that they use more than one brand or model, the calculator used most often is the TI-83/TI-83 Plus by Texas Instruments. This model is used by 26 (72.2%) teachers, with 11 (30.6%) using it exclusively and 15 (41.7%) using it in conjunction with other models. Table 2 shows the responses for calculator brand and model.



Regarding calculator ownership, 17 teachers (47.2%) reported that their students own their own calculators, while 7 teachers (19.4%) noted that their school furnishes calculators for student use. One teacher (2.8%) stated that his or her school rents calculators to students, while 2 teachers (5.6%) use a county-owned set that is rotated among the county high schools. Nine teachers (25%) reported that although their students own calculators, their school also has calculators available for those who need to borrow them. (See Appendix B for the complete compilation of answers to the background questions.)

The second page of the graphing calculator survey consisted of 12 four-point Likert-scale statements (with choices ranging from 1 = Strongly Disagree to 4 = Strongly Agree) concerning calculator use and beliefs about learning algebra. Table 3 gives the frequency and chi-square values for each response.

Table 3

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

Question	1	2	3	4	χ^2
13. My students only use graphing calculators to check their work once they have solved a problem on paper. +	8	19	7	1	19.29*
14. My students often use graphing calculators as a computational tool.	1	4	18	13	20.67*
15. My students use graphing calculators for discovery/exploratory activities. +	1	2	20	12	27.74*
16. My students use the programming feature of their calculators to evaluate basic algebraic formulas (i.e. midpoint, distance, laws of sines and cosines, etc.) ++	15	10	7	2	10.47**
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand. +	0	1	15	19	32.09*
18. My students only use graphing calculators after they have mastered a concept or procedure. +	2	12	17	4	16.77*
19. When my students use graphing calculators on a regular basis, they become dependent on them, and thus are unable to master basic algebraic manipulations.	4	18	12	2	18.22*
20. Using a graphing calculator to teach algebra allows me to emphasize the experimental nature of the subject. +++	0	4	25	4	46.64*
21. I often do not have time to teach both the required algebra curriculum and graphing calculator technology. +	4	14	14	3	12.66*
22. Memorizing certain facts and rules is of primary importance in learning algebra. ++++	2	6	15	12	11.74*
23. When learning algebra, being able to do a procedure is more important than knowing why it works.	14	17	5	0	20.67*
24. Learning algebra means exploring problems to discover patterns and make generalizations. ++++	0	2	23	10	37.34*

+One teacher did not answer this question
++Two teachers did not answer this question
+++Two teachers did not answer this question, one teacher marked 3.5
++++One teacher marked 2.5
*p<.01
**p<.05

When combining the responses of Strongly Disagree/Disagree and Strongly Agree/Agree, the results indicate that 86.1% of the teachers use calculators as a computational tool, 91.4% use calculators for discovery activities, and 97.1% use calculators to graph linear and quadratic equations. A majority of the teachers (73.5%) do not use the programming feature of their calculators and a majority (77.1%) also do not believe that calculators should be used only as a tool to check paper-and-pencil work. In regard to calculator philosophy, 60% believe that calculators should be used only after mastery of a procedure, while 40% do not. There is a concern by 61.1% of the teachers that students become dependent on calculators, and thus are unable to master basic algebraic manipulations. A majority of the teachers (88.2%) believe that using calculators allow them to emphasize the experimental nature of algebra, however about half (51.4%) often do not have time to teach graphing calculator technology along with the required algebra curriculum.

In reference to beliefs about learning algebra, 73.3% of the teachers believe that memorizing facts and rules is of primary importance, while only 10.9% believe that knowing how to do a procedure is more important than knowing why it works. Nearly all the teachers (95.6%) believe that learning algebra means to discover patterns and make generalizations, although one teacher commented that it means much more than just that, and another believes that the time constraints placed on teachers by the state proficiency tests force teachers to avoid discovery methods and teach procedures only. (See Appendix B for the percentage compilation of the Likert-scale responses.)

Based on a process by Tharp, et al. (1997), each teacher's view of learning algebra was determined by compiling his or her responses to question #22 (Memorizing certain

facts and rules is of primary importance in learning algebra), question #23 (When learning algebra, being able to do a procedure is more important than knowing why it works), and question #24 (Learning algebra means exploring problems to discover patterns and make generalizations). Since question #24 is worded opposite of questions #22 and #23, the responses to #22 and #23 were added to the inverse of #24 (4 minus the response) to form a composite score ranging from 3 - 12, determining whether the teacher had a "rule-based" or "non-rule-based" view of learning algebra (Tharp, et al.). To be considered a rule-based teacher, a score of at least 9 had to be attained on the composite. Since only two teachers in the study scored a 9 and no teacher scored higher than 9, few teachers involved in the study were rule-based in nature. Since an actual rule-based versus non-rule-based analysis could not be completed, the teachers with the three highest scores in the study (7.5, 8, and 9) were compared to the teachers with the three lowest scores in the study (3, 4, and 5) using an independent-measures t-test on their responses to questions #13-21. See Table 4 for the significant results at the .05 level.

Table 4

	Scores 3, 4, 5			Scores 7.5, 8, 9				
Question	**N**	**$\bar{X}$**	**SD**	**N**	**$\bar{X}$**	**SD**	**t**	**p**
20. Using a calculator to teach algebra allows me to emphasize the experimental nature of the subject.	5	3.40	.548	9	2.78	.441	2.33	.038

When all 36 teachers who use calculators were included in the test and the responses of the 17 lowest scoring teachers (3-6.5) were compared to the responses of the 19 highest scoring teachers (7-9), no significant results occurred at the .05 level. When comparing the 12 teachers who do not use calculators to the 36 teachers who do, their

responses to the questions concerning their views of learning algebra (#22-24) also showed no significant results at the .05 level.

According to Fleener (1995), teachers' philosophical views can also be determined by their answer to question #18 (My students only use graphing calculators after they have mastered a concept or procedure). The teachers were divided into two groups, mastery and non-mastery, based on their response to question #18. The 21 teachers who answered 3 or 4 (Agree or Strongly Agree) were placed in the mastery group and the 14 who responded with a 1 or 2 (Disagree or Strongly Disagree) were placed in the non-mastery group. When an independent-measures t-test was used to compare the two groups' answers to questions #13-21, no significant results occurred at the .05 level, thus not supporting the view that mastery versus non-mastery is a divisive issue (Fleener).

To determine if the demographic characteristics of gender and years of teaching affected a teacher's calculator use and view of learning algebra, an independent-measures t-test was used. When males were compared to females, the only questions producing significant results were #17 and #22 as presented in Table 5. When comparing teachers who have taught math more than ten years to those who have taught math less than ten years, no significant results at the .05 level occurred.

Table 5

	Females			Males				
Question	N	$\bar{X}$	SD	N	$\bar{X}$	SD	t	p
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand.	18	3.72	.461	17	3.29	.588	2.41	.022
22. Memorizing certain facts and rules is of primary importance in learning algebra.	19	2.74	.991	17	3.38	.546	2.38	.023

In the background information, 26 (72.2%) teachers who use calculators responded that they had attended at least one graphing calculator workshop, while 10 (27.8%) responded that they had not attended any workshops. To investigate whether workshop attendance had any effect on calculator use, an independent-measures t-test was performed on the responses to questions #13-21, using workshop attendance as the independent variable. Table 6 shows the questions with significant results.

Table 6

	Workshops			No Workshops				
Question	N	$\bar{X}$	SD	N	$\bar{X}$	SD	t	p
15. My students use graphing for discovery/exploratory activities.	26	3.38	.571	9	2.78	.833	2.43	.020
16. My students use the programming feature of their calculators to evaluate basic algebraic formulas.	26	1.65	.892	9	2.44	.882	2.30	.028
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand.	26	3.65	.485	9	3.11	.601	2.72	.010
19. When my students use graphing calculators on a regular basis, they become dependent on them, and thus are unable to master basic algebraic manipulations.	26	2.11	.653	10	2.90	.738	3.12	.004

Since 7 of the 10 teachers who had not attended workshops had scores between 7 - 9 on the rule-based scale, they were compared to the 12 teachers with the same scores who had attended workshops. An independent-measures t-test showed significant results on two questions as reported in Table 7.

Table 7

Question	Workshops $\underline{N}$	Workshops $\bar{X}$	Workshops SD	No Workshops $\underline{N}$	No Workshops $\bar{X}$	No Workshops SD	t	p
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand.	12	3.67	.492	7	3.00	.577	2.68	.016
19. When my students use graphing calculators on a regular basis, they become dependent on them, and thus are unable to master basic algebraic manipulations.	12	2.08	.669	7	2.86	.690	2.41	.028

The final statistical analysis performed on the data was a one-way analysis of variance (ANOVA). The teachers' responses to questions #13-21 were compared by the courses they teach (Algebra I, Algebra II, or both) with no significant results. They were also compared by their degree status (Bachelors, Masters, or Masters Plus) with the only significant difference [F(2,33) = 5.42, p = .009) occurring on question #14 (My students often use graphing calculators as a computational tool). The means and standard deviations for question #14 are presented in Table 8.

Table 8

Bachelors $\underline{N}$	Bachelors X	Bachelors SD	Masters $\underline{N}$	Masters $\bar{X}$	Masters SD	Masters Plus $\underline{N}$	Masters Plus $\bar{X}$	Masters Plus SD	F	p
20	2.9	.788	5	3.2	.447	11	3.7	.483	5.42	.009

CHAPTER V - DISCUSSION

The primary purpose of this study was to investigate what, if any, connection exists between teachers' views of learning algebra and their use of graphing calculators. The goal was to categorize each teacher as rule-based or non-rule-based depending on the "degree to which [he or she] adhered to the view that mathematics learning is mostly oriented toward processes which involve the manipulation of symbols and memorization of facts as opposed to the view that mathematics learning is based on reasoning about relationships and patterns" (Tharp, et al., 1997, p. 555) and to then compare the two groups' use of graphing calculators in their algebra classes. Although the low number of rule-based teachers in the study made it impossible to complete the study entirely as intended, the fact that there were so few rule-based teachers in the study was a significant finding in itself. There has been much discussion in recent years concerning mathematics education and reform, with the emphasis shifting from memorization of facts to problem-solving and mathematical reasoning (NCTM, 1991; Ott, 1994). Although the male teachers ($M = 3.38$, $SD = .546$) were more likely than the female teachers ($M = 2.74$, $SD = .991$) to believe that memorizing facts was of primary importance in learning algebra, it is generally evident from the responses to survey questions #22-24, that the algebra teachers in Allen, Putnam, and Van Wert counties are striving "toward mathematical reasoning [and] away from merely memorizing procedures" (NCTM, p. 3). It is also important to note that there were no rule-based teachers among the 12 participants who do not use calculators, nor were their scores on the view of learning algebra composite any higher ($M = 6.6$, $SD = 1.13$) than those who do use calculators

($M = 6.6$, $SD = 1.35$). It may have been beneficial to have included a question on the survey asking the teachers who do not use calculators to give the reasons for their non-use, but according to their responses to questions #22-24, it can at least be assumed that the reason is not related to the their view of learning algebra.

A majority of the teachers in the study (91.4%) reported that they use calculators for discovery activities, and although it may have been expected that teachers with a more rule-based view of algebra would not do so, when comparing the most rule-based teachers in the study (7 - 9 on the learning algebra composite) to the least rule-based teachers in the study (3 - 5 on the learning algebra composite), no significant results occurred on their responses to question #15 (My students use graphing calculators for discovery/exploratory activities). Although a majority of the teachers (88.2%) also believe that calculators allow them to emphasize the experimental nature of algebra, the less rule-based teachers responded more positively to the statement ($M = 3.4$, $SD = .548$) than the more rule-based teachers ($M = 2.8$, $SD = .441$). This result was significant at the .05 level, $t(12) = 2.33$, $p = .038$. In regard to discovery learning, it may have been advantageous to have included a question on the survey concerning participation in discovery methods workshops or graduate courses, and further research could be done comparing the calculator use of teachers who have attended such workshops to those who have not. A future study investigating a teacher's graphing calculator use before and after participation in a discovery workshop or course would also be beneficial.

In relation to workshop attendance, a notable, albeit unexpected, result of this study was associated with participation in graphing calculator workshops. Although previous research has shown contradictory results in respect to the benefits of calculator

workshops (Copley, Williams, Huang, & Waxman, 1994; Schmitt, 1996; Simonsen & Dick, 1997; Tharp, et al., 1997), when comparing teachers who had attended at least one graphing calculator workshop to those who had not attended any workshops, more significant results occurred in the responses to the calculator-use questions (#13-21) than when any other characteristic was used as the independent variable. Teachers who had attended at least one workshop were more likely to use graphing calculators for discovery activities and graphing linear and quadratic equations, and were less likely to believe that their students become dependent on calculators to the point that their basic algebraic skills decline. It is interesting to note, however, that they were also less likely to use the graphing calculator's programming feature than teachers who had not attended workshops. Although it appears that, at least among the teachers in this study, attending a "workshop on graphing calculator use has opened the doors of many classrooms to calculators" (Tharp, et al., 1997, p. 559), it cannot be determined if these differing views are based solely on workshop attendance. It would be valuable to conduct further research where teachers' calculator use is investigated before and after participating in a calculator workshop.

In conclusion, even though this study was not able to investigate in detail whether rule-based teachers use calculators in different ways than non-rule-based teachers, it did, however, reveal some useful information regarding calculator use in Allen, Putnam, and Van Wert counties. As mentioned previously, the fact that workshop attendance appears to positively affect calculator use will be valuable information to any school administrator or mathematics teacher attempting to institute or increase the use of calculators in their algebra classrooms. Furthermore, it is helpful to know that a majority of the algebra

teachers who use calculators in these three counties are currently using the Texas Instruments TI-83/TI-83 Plus and that they are using them in their classes at least several times per week for in-class activities, homework, quizzes, and tests. It is also valuable to note that the number of years a teacher has taught math and the courses he or she teaches (Algebra I, Algebra II, or both) do not significantly influence calculator use.

REFERENCES

Baggett, P., & Ehrenfeucht, A. (1992). What should be the role of calculators and computers in mathematics education? *Journal of Mathematical Behavior, 11* (1), 61-72.

Ballheim, C. (1999). How our readers feel about calculators. *Mathematics Education Dialogues, 2* (3), 4-5.

Bitter, G. G., & Hatfield, M. M. (1992). Implementing calculators in middle school mathematics: Impact on teaching and learning. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education: 1992 yearbook* (pp. 200-207). Reston, VA: National Council of Teachers of Mathematics.

Bitter, G. G., & Hatfield, M. M. (1994). The calculator project: Assessing school-wide impact of calculator integration. In G. W. Bright, H. C. Waxman, & S. E. Williams (Eds.), *Impact of calculators on mathematics instruction* (pp. 49-65). Lanham, MD: University Press of America, Inc.

Burrill, G. (1992). The graphing calculator: A tool for change. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education: 1992 yearbook* (pp. 14-22). Reston, VA: National Council of Teachers of Mathematics.

Burrill, G. (1997). Computation, calculators, and the "basics". *NCTM News Bulletin, 34*, 3.

Burrill, G. (1999). A revolution in my high school classroom. *Mathematics Education Dialogues, 2* (3), 13.

Copley, J. V., Williams, S. E., Huang, S. L., & Waxman, H. C. (1994). Research on calculator use in middle school mathematics classrooms. In G. W. Bright, H. C. Waxman, & S. E. Williams (Eds.), *Impact of calculators on mathematics instruction* (pp. 67-78). Lanham, MD: University Press of America, Inc.

Dessart, D. J., DeRidder, C. M., & Ellington, A. J. (1999). The research backs calculators. *Mathematics Education Dialogues, 2* (3), 6.

Dion, G. (1990). The graphics calculator: A tool for critical thinking. *Mathematics Teacher, 83* (7), 564-571.

Drier, H. S., Dawson, K. M., & Garofalo, J. (1999). Not your typical math class. *Educational Leadership,* 21-25.

Drijvers, P., & Doorman, M. (1996). The graphics calculator in mathematics education. *Journal of Mathematical Behavior, 15*, 425-440.

Dunham, P. H., & Dick, T. P. (1994). Research on graphing calculators. *Mathematics Teacher, 87* (6), 440-445.

Fine, A. E., & Fleener, M. J. (1994). Calculators as instructional tools: Perceptions of three preservice teachers. *Journal of Computers in Mathematics and Science Teaching, 13* (1), 83-100.

Fleener, M. J. (1995). A survey of mathematics teachers' attitudes about calculators: The impact of philosophical orientation. *Journal of Computers in Mathematics and Science Teaching, 14* (4), 481-498.

Gay, L. R. (1996). *Educational research* (5th ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

Gilchrist, M. E. (1993). *Calculator use in mathematics instruction and standardized testing: An adult education inquiry. Review of the literature, 1976-1993.* (ERIC Document Reproduction Service No. ED 372 919)

Glasgow, B., & Reys, B. J. (1998). The authority of the calculator in the minds of college students. *School Science and Mathematics, 98* (7), 383-388.

Heid, M. K. (1988). Calculators on tests – one giant step for mathematics education. *Mathematics Teacher, 81* (9), 710-713.

Hembree, R., & Dessart, D. J. (1992). Research on calculators in mathematics education. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education: 1992 yearbook* (pp. 23-32). Reston, VA: National Council of Teachers of Mathematics.

Huang, S. L. (1993). Investigating middle school students' attitudes toward calculator use. In D. Carey, D. Carey, D. A. Willis, & J. Willis (Eds.), *Technology and teacher education annual: 1993* (pp. 514-518). Charlottesville, VA: Association for the Advancement of Computing in Education.

Kenelly, J. (1990). Using calculators in the standardized testing of mathematics. *Mathematics Teacher, 83* (9), 716-720.

Klenow, C. (1993). The case for calculators. *Instructor, 102* (8), 80-81.

Kramer, S. L. (1996). Block scheduling and high school mathematics instruction. *Mathematics Teacher, 89* (9), 758-768.

Maier, G. (1983). We have a choice. *Mathematics Teacher, 76* (6), 386-387.

Mercer, J. (1992). What is left to teach if students can use calculators? *Mathematics Teacher, 85* (6), 415-417.

Merriweather, M., & Tharp, M. L. (1999). The effect of instruction with graphing calculators on how general mathematics students naturalistically solve algebra problems. *Journal of Computers in Mathematics and Science Teaching, 18* (1), 7-22.

Mikesell, A. (2000). Ohio Department of Education update: The development of the High School Graduation Qualifying Examination in Mathematics. *Ohio Journal of School Mathematics*, (41), 4-8.

Milou, E. (1999). The graphing calculator: A survey of classroom usage. *School Science and Mathematics, 99* (3), 133-139.

National Council of Teachers of Mathematics (NCTM). (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (NCTM). (1991). *Professional standards for teaching mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Ostapczuk, E. D. (1994). *The status of hand held calculators in secondary mathematics: An examination of issues and uses in the classroom throughout the Mid-Hudson Valley region*. (ERIC Document Reproduction Service No. ED 380 410)

Ott, J. (1994). *Alternative assessment in the mathematics classroom*. New York: Glencoe/McGraw-Hill.

Penglase, M., & Arnold, S. (1996). The graphics calculator in mathematics education: A critical review of recent research. *Mathematics Education Research Journal, 8* (1), 58-90.

Podlesni, J. (1999). A new breed of calculators: Do they change the way we teach? *Mathematics Teacher, 92* (2), 88-89.

Ralston, A. (1991). Calculators for teaching and testing: A mathematician's view. *College Board Review*, (160), 18-21.

Reys, R. E., Reys, B. J., Barger, R., Hauck, J., Morton, L., Reehm, S., Sturdevant, R, & Wyatt, J. (1990). *Calculator use in mathematics teaching in Missouri schools: A 1990 status report.*

Reys, R. E., Reys, B. J., & Wyatt, J. W. (1993). Graphing calculators. *Mathematics Teacher, 86* (3), 261.

Schmitt, D. R. (1996). *Evaluation of mathematics reform*. Paper presented at the Annual Conference of the Association of Louisiana Evaluators. New Orleans, LA.

Simmt, E. (1997). Graphing calculators in high school mathematics. *Journal of Computers in Mathematics and Science Teaching, 16* (2/3), 269-289.

Simonsen, L. M., & Dick, T. P. (1997). Teachers' perceptions of the impact of graphing calculators in the mathematics classroom. *Journal of Computers in Mathematics and Science Teaching, 16* (2/3), 239-268.

Tharp, M. L., Fitzsimmons, J. A., & Brown Ayers, R. L. (1997). Negotiating a technological shift: Teacher perception of the implementation of graphing calculators. *Journal of Computers in Mathematics and Science Teaching, 16* (4), 557-575.

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*, 105-112.

Tress, M. (1998). Visual learners. *Curriculum Administrator, 34* (4), 24.

Trotter, A. (1991). Graphing calculators are coming to class. *Executive Educator, 13* (1), 20.

Usiskin, Z. (1984). Mathematics is getting easier. *Mathematics Teacher*, 77 (2), 82-83.

Usiskin, Z. (1999). Groping and hoping for a consensus on calculator use. *Mathematics Education Dialogues, 2* (3), 1.

Waits, B. K., & Demana, F. (1996). A computer for all students revisited. *Mathematics Teacher, 89* (9), 712-714.

West, P. (1991). Sold on a new machine. *Teacher Magazine, 3* (2), 18-19.

APPENDIX A
TEACHER COVER LETTER

Dear Algebra Teacher:

I am a math teacher at Delphos Jefferson High School and am currently a student in the Masters of Education program at Bluffton College. As part of the requirement for the completion of my degree, I am conducting a research project on graphing calculator use in high school algebra classrooms.

To conduct my research I am surveying all Algebra I and II teachers in Allen, Putnam, and Van Wert counties about their calculator use. It would be greatly appreciated if you would take the time to complete the enclosed questionnaire and return it to me in the included envelope by Friday, February 18. Please do not include your name on the questionnaire, as all data obtained from the surveys will be kept confidential and only summaries that contain no identifying factors will be included in the final report.

If you would like a copy of the final report, please complete the form below and return it to me in a separate envelope and I will send you the completed research study later this spring. If you have any questions pertaining to the study, please contact me at one of the following numbers:

(419) 695-1786 or dl_yoder@noacsc.org (school)
(419) 692-1540 or ajy6162@wcoil.com (home)

Thank you for your time and consideration.

Sincerely,

Arnita Yoder
Box 253
Delphos, Ohio 45833

Please send me a copy of the completed research study.

Name ______________________________

Address______________________________

City____________State____________Zip_________

APPENDIX A
GRAPHING CALCULATOR SURVEY - PAGE 1

(If you do not use graphing calculators in your algebra classes, please complete questions # 1-7 and 22-24.)

1. How many years have you taught math? __________

2. What is your gender? _____ Male _____ Female

3. What is your age? __________

4. What is your highest degree? _____ Bachelors _____ Masters _____ Masters Plus

5. Have you attended any graphing calculator workshops?
_____Yes (How many?_________) _____ No

6. Which Algebra classes do you teach? _____ Algebra I _____ Algebra II _____ Both

7. In which classes do your students use graphing calculators?
_____ Algebra I _____ Algebra II _____ My students do not use graphing calculators.

8. How many years have you used graphing calculators in your algebra classes?__________

9. What brand(s)/model(s) of graphing calculator(s) do your students use?____________________________

10. Do your students own calculators or does the school furnish calculators for student use?
_____ Students Own _____ School Furnishes _____ Other (Please explain)

11. When do your algebra students use graphing calculators? (Check all that apply.)
____ To do in-class activities and assignments
____ To do homework
____ To take quizzes
____ To take tests
____ Other (Please Describe____)

12. Approximately how often do your algebra students use graphing calculators?
_____ Every day
_____ Several times per week
_____ Several times per month
_____ Less than once per month

APPENDIX A
GRAPHING CALCULATOR SURVEY - PAGE 2

1 = Strongly Disagree   2 = Disagree   3 = Agree   4 = Strongly Agree

13. My students only use graphing calculators to check their work once they have solved a problem on paper.	1	2	3	4
14. My students often use graphing calculators as a computational tool.	1	2	3	4
15. My students use graphing calculators for discovery/exploratory activities.	1	2	3	4
16. My students use the programming feature of their calculators to evaluate basic algebraic formulas (i.e. midpoint, distance, laws of sines and cosines, etc.).	1	2	3	4
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand.	1	2	3	4
18. My students only use graphing calculators after they have mastered a concept or procedure.	1	2	3	4
19. When my students use graphing calculators on a regular basis, they become dependent on them, and thus are unable to master basic algebraic manipulations.	1	2	3	4
20. Using a graphing calculator to teach algebra allows me to emphasize the experimental nature of the subject.	1	2	3	4
21. I often do not have time to teach both the required algebra curriculum and graphing calculator technology.	1	2	3	4
22. Memorizing certain facts and rules is of primary importance in learning algebra.	1	2	3	4
23. When learning algebra, being able to do a procedure is more important than knowing why it works.	1	2	3	4
24. Learning algebra means exploring problems to discover patterns and make generalizations.	1	2	3	4

APPENDIX A
TEACHER FOLLOW-UP LETTER

February 21, 2000

Dear Algebra Teacher:

Due to the number of school cancellations and schedule changes during the last two weeks, I am extending the deadline for the return of my graphing calculator research survey. If you have not returned your survey, but can do so by Tuesday, February 29, I will still be able to use your input in my final research report.

If you need another copy of the survey or if you have any other questions, please contact me at one of the following numbers:

(419) 695-1786 or dl_yoder@noacsc.org (school)
(419) 692-1540 or ajy6162@wcoil.com (home).

Thank you again for your time and consideration.

Sincerely,

Arnita Yoder
Box 253
Delphos, Ohio 45833

APPENDIX B
GRAPHING CALCULATOR SURVEY - RESULTS

Note: The 12 teachers who do not use calculators only answered questions #1-7 and 22-24.

1. How many years have you taught math?

   1-10 years - 19
   11-20 years - 9
   21-30 years - 16
   Over 30 years - 4

2. What is your gender?

   Male - 24
   Female - 24

3. What is your age?

   21-30 years - 15
   31-40 years - 9
   41-50 years - 14
   51 years or older - 10

4. What is your highest degree?

   Bachelors - 23
   Masters - 11
   Masters Plus - 14

5. Have you attended any graphing calculator workshops?

   Yes - 34 (Number: one - 9 two - 17 three - 3 four or more - 3 no answer - 2)
   No - 14

6. Which Algebra classes do you teach?

   Algebra I - 21
   Algebra II - 16
   Both - 11

7. In which classes do your students use graphing calculators?

Algebra I - 12
Algebra II - 15
Both - 8
No answer - 1
Don't use calculators - 12

8. How many years have you used graphing calculators in your algebra classes?

1-3 years - 13
4-6 years - 13
7-9 years - 4
10 years or more - 5
No answer - 1

9. What brand(s)/model(s) of graphing calculator(s) do your students use? (Teachers could give more than one answer to this question.)

TI-83/TI-83 Plus - 26
TI-82 - 12
TI-81 - 9
TI-85 - 9
TI-86 - 4
TI-92 - 1
TI-95 - 1
Casio - 4
Sharp - 1

10. Do your students own calculators or does the school furnish calculators for student use? (Teachers could give more than one answer to this question.)

Students own - 17
School furnishes - 7
Both - 11
Use county-owned calculators - 2
Students rent - 1

11. When do your algebra students use graphing calculators? (Check all that apply.)

To do in-class activities and assignments only - 5
To do homework only - 0
To take quizzes only - 0
To take tests only - 0
All of the above - 28
All of the above except homework - 2
All of the above except quizzes - 1

12. Approximately how often do your algebra students use graphing calculators?

Every day - 10
Several times per week - 13
Several times per month - 6
Less than once per month - 6
No answer - 1

1 = Strongly Disagree 2 = Disagree 3 = Agree 4 = Strongly Agree

	SD/D	SA/A
13. My students only use graphing calculators to check their work once they have solved a problem on paper.	77.1%	22.9%
14. My students often use graphing calculators as a computational tool.	13.9%	86.1%
15. My students use graphing calculators for discovery/exploratory activities.	8.6%	91.4%
16. My students use the programming feature of their calculators to evaluate basic algebraic formulas (i.e. midpoint, distance, laws of sines and cosines, etc.)	73.5%	26.5%
17. My students use graphing calculators to graph linear and quadratic equations that were once only graphed by hand.	2.9%	97.1%
18. My students only use graphing calculators after they have mastered a concept or procedure.	40.0%	60.0%
19. When my students use graphing calculators on a regular basis, they become dependent on them, and thus are unable to master basic algebraic manipulations.	61.1%	38.9%
20. Using a graphing calculator to teach algebra allows me to emphasize the experimental nature of the subject.	11.8%	88.2%
21. I often do not have time to teach both the required algebra curriculum and graphing calculator technology.	51.4%	48.6%
22. Memorizing certain facts and rules is of primary importance in learning algebra.	26.7%	73.3%
23. When learning algebra, being able to do a procedure is more important than knowing why it works.	89.1%	10.9%
24. Learning algebra means exploring problems to discover patterns and make generalizations.	4.4%	95.6%

SE064246 [redacted]

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

031953

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: The Relationship Between Graphing Calculator Use and Teachers' Beliefs About Learning Algebra.	
Author(s): Arnita J Yoder	
Corporate Source: —	Publication Date: —

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Arnita J Yoder	Printed Name/Position/Title: Arnita J Yoder	
Organization/Address: Box 253 Delphos, Ohio 45833	Telephone: 419-692-1540	FAX: (none)
	E-Mail Address: ajy6162@wcoil.com	Date: 10-13-2000

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

ERIC CLEARINGHOUSE ON ASSESSMENT AND EVALUATION
UNIVERSITY OF MARYLAND
1129 SHRIVER LAB
COLLEGE PARK, MD 20742
ATTN: ACQUISITIONS

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
4483-A Forbes Boulevard
Lanham, Maryland 20706

Telephone: 301-552-4200
Toll Free: 800-799-3742
FAX: 301-552-4700
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com